

Agricultural Commodity Price Shocks and Their Effect on Growth in Sub-Saharan Africa

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Abstract

Commodity price shocks are an important type of external shock and are often cited as a problem for economic growth in Sub-Saharan Africa. We choose nine Sub-Saharan African countries that are heavily dependent on a single agricultural commodity for a significant portion of their income. This paper quantifies the impact of agricultural commodity price shocks using a structural non-linear dynamic model. The novel aspect of this study is that we determine whether the response of per capita GDP for the selected Sub-Saharan African countries is different to unexpected increases in agricultural commodity prices as opposed to decreases in prices. We conclude that there is very little evidence that an unanticipated price increase (decrease) will lead to a significantly different response in per capita incomes.

Keywords: *Commodity prices; economic growth; external shocks; price shocks.*

JEL classifications: *E30, F40, O11.*

1. Introduction

External shocks, such as large fluctuations in commodity prices and natural disasters, are often cited as reasons for low and unstable growth in low-income countries

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(LICs), especially in Sub-Saharan Africa (SSA). The World Bank, IMF and UNCTAD have emphasised that commodity prices, in particular, have an important influence on economic growth and on the incidence of poverty in LICs. SSA countries are mostly heavily dependent on the export of a single or few commodities. For many countries at least half of their income depends on the exports of just a few commodities. As a result large shocks to commodity prices can have a large impact on individual incomes, which in turn affects the well-being of a country's population.

Although in recent years SSA countries have experienced a general increase in economic growth, for at least the last half century, economic growth in SSA countries has been slow (Easterly and Levine, 1997; Ndulu and O'Connell, 2007). Using data from the World Development Indicators, Anderson and Bruckner (2012) calculate that the average share of GDP from agriculture in SSA countries during the past half century has been more than a third. Even with the recent increase in economic growth in selected SSA countries, agricultural production in SSA accounts for approximately a quarter of total GDP (Sandri *et al.*, 2007).

There has been a diversity of experience in terms of economic growth in SSA. Certain countries have performed better than others and alongside the nature of governance, commodity prices have been a crucial factor in promoting economic growth. Though most SSA countries are dependent on primary commodities as their main source of income, the mix of these commodities varies from country to country and some commodities are more important to certain countries than others. Besides, the diversity arises because it is well known that unrelated primary commodities do not move together (see Deb *et al.*, 1996; Ai *et al.*, 2006). Indeed, such diversity of experience in different SSA countries is found in the study by Bevan *et al.* (1993).

It has been argued that some developing countries have responded poorly to commodity price shocks thus exacerbating debt problems and have experienced very low rates of economic growth. This may have been a result of not being able to reap the gains from positive shocks and being unable to prevent large losses from negative shocks. For example, many governments responded to commodity price booms in the late 1970s by sharply expanding public expenditure for import-intensive public investment programmes (Cashin *et al.*, 2004). Subsequently, when commodity prices declined steeply, these programmes either had to be abandoned or financed with foreign borrowing. Agricultural commodities constitute a large cash flow of most investment projects in the selected SSA economies chosen in this study. Since the cash flows for such irreversible investment projects depend on the price of commodities (Bernanke, 1983), an unexpected increase or decrease in commodity prices causes uncertainty that may amplify the effects of price decreases compared with increases which may lead to an asymmetric response in real GDP growth (Kilian, 2014).

Since agriculture accounts for a large share of income in many rural households, policies and external shocks that affect agriculture can be expected to have a significant impact on poverty (Baumeister and Kilian, 2014). Bevan *et al.* (1993) find marked increases in farmers' savings in response to the 1976–1977 coffee boom in SSA. Deaton and Miller (1996) find in the short run that when commodity prices increase they have a positive impact on economic growth in African countries in comparison to a commodity price decreases. However, Collier and Gunning (1999) find that windfalls from commodity price shocks do not translate into sustainable increases in income. Evidence for SSA (see Dehn, 2000) points to possible asymmetry; where price booms are less likely to have a lasting effect on economic growth than price slumps because windfall profits associated with booms tend to be consumed

rather than invested; whereas slumps may force farmers to disinvest. Many studies allow for multiplier effects via forward and backward linkages but typically neglect that these effects may be confined to specific regions due to limited spatial integration (Giordani *et al.*, 2014). Varangis *et al.* (2004) echo the importance of distinguishing positive and negative shocks. They argue that the effect of external shocks on economic growth is asymmetric and reason that positive shocks do not offset negative ones partly because negative shocks have irreversible effects. When commodity prices experience a positive shock, this leads to increased foreign exchange earnings which may lead to an excessive appreciation of the real exchange rate. This makes other tradeable sectors less competitive in global markets and, ultimately, can lead to a decline in their output, known as the Dutch disease. In a related study, Collier and Goderis (2012) find that in the short run, commodity booms have positive effects on output; however, in the long run the effect on output largely depends on the type of commodity and the quality of governance. In another recent study, Anderson and Bruckner (2012) show that increases in distortions to relative agricultural prices have a significant negative effect on economic growth in Sub-Saharan African countries. Collier (2007) notes that price changes in agricultural commodities have very different effects from those of non-agricultural commodities. For example, agricultural commodity booms had been badly managed in SSA due to excessive taxation. Collier and Goderis (2009) highlight the importance of positive and negative price shocks when considering whether aid can mitigate the effects of such shocks. The upshot is that agricultural prices can have a significant impact on economic growth in SSA countries and that one may expect the response to a positive shock in commodity prices to be different from a negative price shock.

We study the effects of agricultural price shocks on the *per capita* incomes of SSA countries.² Following the reasoning put forward by Collier and Gunning (1999), Dehn (2000) and Varangis *et al.* (2004) regarding the possible asymmetry in response to commodity price shocks, we determine whether a positive commodity price shock has a larger effect than a negative commodity price shock. To this end we adopt the procedure proposed by Kilian and Vigfusson (2011a) that allows us to separately distinguish the response of *per capita* economic growth to positive and negative price shocks.

The possibility of whether price shocks matter for economic growth in SSA, and whether price increases as opposed to decreases matter, is an empirical question. The importance of asymmetric shocks to output in SSA countries has been highlighted in studies by Houssa (2008) and Fielding and Shields (2001); albeit these studies focus on demand and supply shocks. However, Houssa (2008) notes and recommends as a subject for future research the importance of the effect of commodity price shocks and the disaggregation of these shocks on the output of SSA countries as being crucial to the successful implementation of stabilisation policies.

This study adds to the literature in a crucial dimension by aiming to be more specific about whether agricultural commodity price shocks matter for growth, and if so, to measure their impact and to document their robustness. To our knowledge, such studies of agricultural price shocks have not been analysed in terms of their effect on

²Whether *per capita* GDP is an appropriate measure of inclusive growth remains a debatable issue. However, Garcia-Verdu *et al.* (2012) find that high *per capita* economic growth is closely linked to inclusive growth when considering a selection of SSA countries.

economic growth in SSA. We obtain a unique perspective in coverage by carefully selecting commodities that constitute a large or significant share of exports for selected SSA countries and study the effects for each country individually. Riddell (2007) argues that a country-based approach provides reliable evidence and this view has been corroborated by Juselius *et al.* (2014).

This paper is structured as follows: The next section describes the literature review, followed by a description of our econometric methods. Section 4 describes the data and empirical results. The last section concludes.

2. Literature Review

Bleaney and Greenaway (2001) estimate a panel data model for a sample of 14 SSA countries over the period 1980–1995 and show that growth is negatively affected by terms of trade volatility, and investment by real exchange rate instability. Blattman *et al.* (2007) investigate the impact of terms of trade volatility, arising from excessive commodity price fluctuations, on the growth performance of a panel of 35 commodity-dependent countries between 1870 and 1939. Using a panel database, they provide evidence of the adverse effects of volatility on foreign investment and, through that, on economic growth in what they call ‘periphery’ nations. Blattman *et al.* (2007) using historical data find that countries experiencing more volatile commodity prices tend to grow more slowly than countries experiencing relatively stable price movements. In addition when commodity prices show a favourable trend, the core countries tend to perform better than their peripheral counterparts. Aghion *et al.* (2009), using a system GMM dynamic panel data method for 83 countries over the period 1960–2000, show that higher levels of exchange rate volatility can stunt growth, especially in countries where capital markets are thin and where financial shocks are the main source of macroeconomic volatility.

Commodity prices are known to be volatile and it has been suggested that natural resource prices in particular have been largely detrimental to growth (Hausmann and Rigobon, 2003; Blattman *et al.*, 2007). Auty (1993) described the phenomenon of the ‘natural resource curse’ where countries endowed with natural resources experience low economic growth in comparison to countries who achieve high economic growth with little or no natural resources. However, the empirical evidence regarding the impact of natural resource prices on economic growth is mixed, with some confirming Sachs and Warner’s (1999) results of a negative effect on growth (see Rodriguez and Sachs, 1999; Gylfason *et al.*, 1999; and Bulte *et al.*, 2005 among others). On the other hand, a growing number of papers provide evidence against the resource curse hypothesis (see Brunnschweiler and Bulte, 2008; Alexeev and Conrad, 2009).

This paper contributes to several strands of the literature that have explored the link between external shocks and real economic activity in low income countries. For example, Easterly *et al.* (1993) showed, using growth regressions, that variation in the growth of terms of trade could explain a large part of the variation in the economic growth of a selection of countries. Mendoza (1995) and Kose and Riezman (2001) adopt calibrated general equilibrium models and find that almost half of output fluctuations in LICs can be accounted for by terms of trade shocks. However, using a different methodological approach (Vector Autoregressive or VAR models) Deaton and Miller (1996) and Hoffmaister *et al.* (1998) found that terms of trade shocks account for a small fraction of output volatility. Broda

(2004) employed a panel VAR approach and found that terms of trade shocks have a larger output impact in countries with fixed exchange rates. Raddatz (2007) also employed a panel VAR model to find that external shocks play a small but significant role in explaining output volatility. Collier and Goderis (2012) adopt a panel error correction model to study the effect of commodity prices on output *per capita*, separating the long-term and short-term effects. Their results show that commodity price increases have an impact on *per capita* GDP in the short term; however, for countries that have poor governance, the long-term effects of commodity price booms are negative (reflecting mismanagement of the export revenues when governance is weak).

Recent studies on external shocks and their impact on economic activity (such as Broda, 2004; Raddatz, 2007; Collier and Goderis, 2012) have employed a panel VAR or panel ECM approach. A major drawback of these studies is that the dynamics are common across cross-sectional units. This assumption is driven by the fact that with the limited time series data available, the country-specific dynamics cannot be estimated. However, Pesaran and Smith (1995) observe that this assumption will probably result in underestimation (overestimation) of short-run (long-run) impacts of the shocks if the dynamics differ across countries. Juselius *et al.* (2014) also note that panel models require fairly strict assumptions. While Raddatz (2007) argues that this criticism can be mitigated by choosing countries that are relatively homogeneous, we find our results from individual country evidence confirm the heterogeneity of experience. Besides, the explanatory variables are likely to be heterogeneous. As a case in point, the dynamics of individual commodity prices which may be closely related (such as cocoa and coffee), have been found by recent studies (see Kellard and Wohar, 2006; Ghoshray, 2011; Ghoshray *et al.*, 2014) to exhibit dynamics that are widely different. These studies have recommended against using aggregate indices that constitute a group of commodities (such as metals, beverages, etc.) and have concluded that individual commodities should be modelled separately.

3. Econometric Methodology

We follow Kilian and Vigfusson (2011a) to quantify the degree of asymmetry in the response to positive and negative commodity price shocks. This approach also formally tests whether the response functions are symmetric in commodity price increases and decreases, taking account of the fact that the answer may depend on the magnitude of the price shock.

The standard linear model of the linear relationship between domestic economic growth and changes in real commodity prices is:

$$\begin{aligned}\Delta x_t &= b_{10} + \sum_{i=1}^p b_{11,i} \Delta x_{t-i} + \sum_{i=1}^p b_{12,i} \Delta y_{t-i} + \varepsilon_{1,t} \\ \Delta y_t &= b_{20} + \sum_{i=0}^p b_{21,i} \Delta x_{t-i} + \sum_{i=1}^p b_{22,i} \Delta y_{t-i} + \varepsilon_{2,t}\end{aligned}\tag{1}$$

where Δy_t and Δx_t denote the differenced log variables of *per capita* economic growth and agricultural price changes, respectively. The error terms $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are white

noise processes, determined by the appropriate lag length selection of the VAR chosen according to the Schwarz Information Criterion (SIC).³

This model implies that the responses to positive and negative real commodity price shocks are symmetric. If we wish to allow for asymmetric responses, (1) must be generalised to include additional censored regressors, so that we allow for only positive values of x_t (denoted by x_t^+) in the second equation of (1). Following Mork (1989), the censored regressor is constructed as:

$$\Delta x_t^+ = \max[0, \Delta x_t].$$

And the non-linear dynamic model is:

$$\begin{aligned} \Delta x_t &= b_{10} + \sum_{i=1}^p b_{11,i} \Delta x_{t-i} + \sum_{i=1}^p b_{12,i} \Delta y_{t-i} + \varepsilon_{1,t} \\ \Delta y_t &= b_{20} + \sum_{i=0}^p b_{21,i} \Delta x_{t-i} + \sum_{i=1}^p b_{22,i} \Delta y_{t-i} + \sum_{i=0}^p g_{21,i} \Delta x_{t-i}^+ + \varepsilon_{2,t}. \end{aligned} \quad (2)$$

In this case, the model allows us to separate commodity price increases from commodity price decreases, therefore allowing a test for symmetry of prices on the *per capita* GDP. The first equation of (2) is identical to the first equation of (1); but the second equation in (2) includes x_t and x_t^+ and as such, allows for commodity price increases to affect *per capita* GDP differently from price decreases.

Finally, we can allow for the possibility that the response of economic growth depends not only on the sign of the change in the real commodity price, but also on whether the real commodity price increase is large relative to its maximum level over the last 3 years. Following the definition of a ‘net price increase’ by Hamilton (1996, 2003), the censored regressor is defined as:

$$\Delta x_t^{+,net} = \max[0, x_t - \max\{x_{t-1}, x_{t-2}, \dots, x_{t-n}\}]$$

where n is the exogenously chosen period; in this study set to 3 years. The net price increase is therefore equal to the maximum of zero and the difference between the log-level of agricultural commodity price for the current year and the maximum value of the logged agricultural commodity price achieved in the previous 3 years. The structural model is:

$$\begin{aligned} \Delta x_t &= b_{10} + \sum_{i=1}^p b_{11,i} \Delta x_{t-i} + \sum_{i=1}^p b_{12,i} \Delta y_{t-i} + \varepsilon_{1,t} \\ \Delta y_t &= b_{20} + \sum_{i=0}^p b_{21,i} \Delta x_{t-i} + \sum_{i=1}^p b_{22,i} \Delta y_{t-i} + \sum_{i=0}^p g_{21,i} \Delta x_{t-i}^{+,net} + \varepsilon_{2,t}. \end{aligned} \quad (3)$$

To understand why all these factors matter, consider feeding equation (3) with a very large positive shock. For a given commodity price variable x_t , it is very likely that Δx_t will be positive and that x_t^+ will be different from zero, affecting economic growth through the coefficient $g_{21,0}$. Alternatively, the smaller the size of the shock the higher the probability that the term x_t^+ will be zero, resulting in a more muted response of y_t .

³We estimate the model choosing different lag lengths. The results do not change for lag length set equal to 2 and up to 6.

We compute the impulse responses as documented by Kilian and Vigfusson (2011a). We first estimate the unrestricted structural dynamic model as given by (2) or (3) and calculate the unconditional impulse responses to both positive and negative shocks. We then construct a Wald test where the null hypothesis is of symmetric responses to positive and negative shocks. Choosing a time horizon h , the null hypothesis is set up as:

$$I_y^h(\delta) + I_y^h(-\delta) = 0 \quad \text{for } h = 0, 1, 2, \dots, H.$$

The Wald test has an asymptotic χ_{h+1}^2 distribution assuming that the parameter estimates in (2) or (3) are asymptotic normal. The magnitude of the shock is given by δ . To carry out this test an estimate of the variance of $I_y^h(\delta) + I_y^h(-\delta) = 0$ is required, which is obtained using a bootstrap simulation (see Kilian and Vigfusson, 2011a for details).

4. Data and Empirical Results

The two variables of interest in this study are international agricultural commodity prices and the real *per capita* GDP of nine SSA countries. These countries are Benin, Burkina Faso, Burundi, Cameroon, Cote d'Ivoire, Ghana, Malawi, Kenya and Rwanda. The real *per capita* GDP is measured annually in constant 2005 US dollars and obtained from the *World Development Indicators* compiled by the World Bank. For real commodity prices we choose an extended dataset of the original Grilli–Yang Commodity Price Index (GYCPI) which contains commodity price indices of a range of primary commodities.⁴ For this study we choose five commodities from the GYCPI: cocoa, coffee, cotton, tea and tobacco deflated by the Manufacturing Unit Value (MUV) index.⁵ These real commodity price index data are measured annually and can also be treated as a measure of the commodity terms of trade as it reflects the price of exports relative to the price of imports for the selected SSA countries. The sample period considered is 1960–2010 to allow a match with the available *per capita* GDP data for the chosen SSA countries. Table 1 below describes some basic statistics that describe the selected agricultural commodities considered in this study.

Table 1
Basic statistics of commodity prices 1960–2010

Country	AR (1)	AR (2)	C.V.	Skewness	Kurtosis
Cocoa	0.83	0.61	0.51	1.77*	4.01*
Coffee	0.73	0.49	0.45	1.64*	5.56*
Cotton	0.93	0.86	0.43	0.60*	−0.71
Tobacco	0.79	0.49	0.14	0.09	−0.07
Tea	0.88	0.79	0.38	1.01*	−0.23

Notes: * Denotes significance at the 10% level.

⁴We do not use exchange rates in the model as we cannot allow for another variable in the current framework. The GYCPI is a popular index and is used extensively in the literature on trends and cycles in commodity prices. We thank an anonymous referee for raising this point.

⁵The extended Grilli–Yang data are obtained from <http://www.stephan-pfaffenzeller.com/cpi.html>. Details about the updating of data can be found in Pfaffenzeller *et al.* (2007).

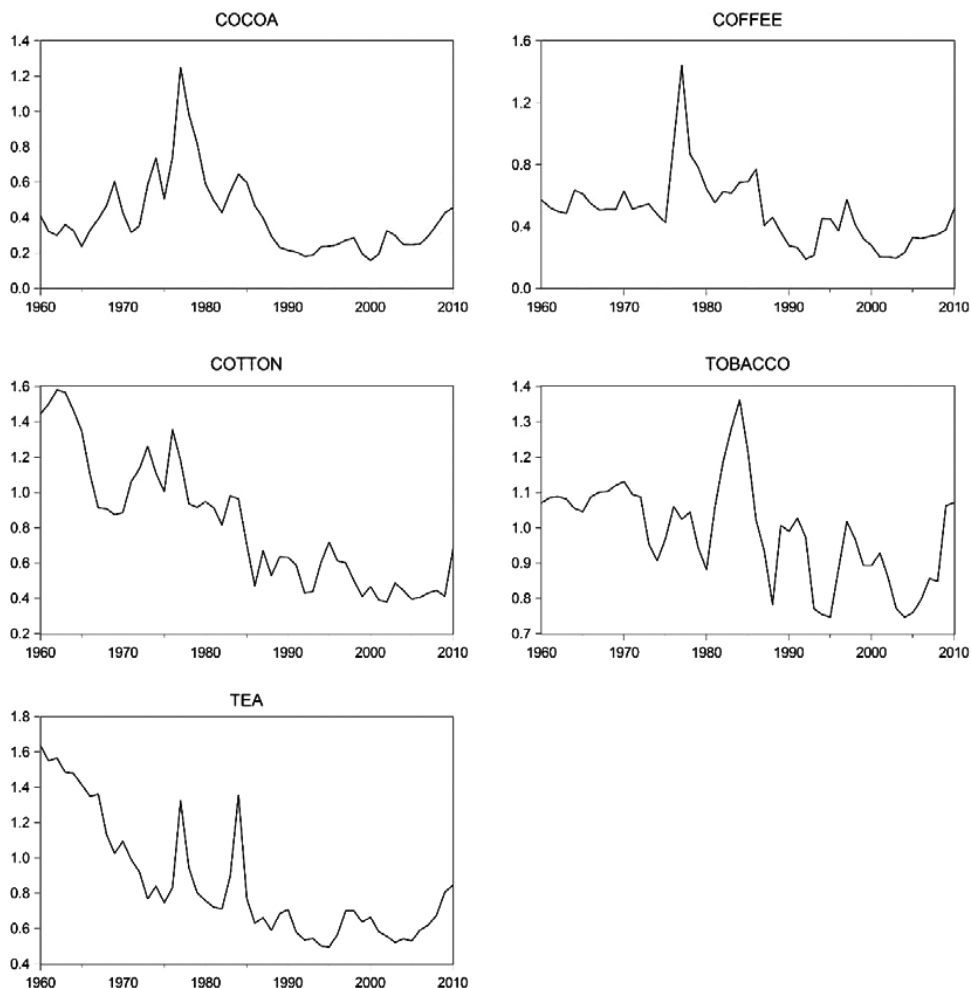


Figure 1. Real commodity prices

We find that the agricultural commodity prices considered are characterised with first order autocorrelation coefficients of at least 0.73, with more than half of the commodities being roughly around 0.83 or greater. The second order correlation coefficients are lower but are still substantial. The coefficient of variation shows that cocoa is most volatile. For the rest of the commodities, although the volatility is lower, there is a considerable amount of variability in prices. All the commodities show positive skewness, which implies that these commodities experience more frequent upward spikes than downward spikes. Substantial kurtosis is found for coffee and cocoa, which means that when considering the distribution of these prices, the tails are thicker than those of a normal distribution. Figure 1 below shows the plots of the real commodity prices.

The nine SSA countries selected for this study have been carefully selected given their dependency on agricultural commodities for their income as well as the availability of data. Many of these SSA countries have open economies with the exports of a single commodity corresponding to a high percentage of their GDP. Table 2 below

Table 2
Export earnings of a single commodity as a percentage of GDP

Country	Commodity	% of commodity exports 2009–2010
Benin	Cotton	38
Burkina Faso	Cotton	44
Burundi	Coffee	61
Cameroon	Cocoa	16
Cote d'Ivoire	Cocoa	39
Ghana	Cocoa	49
Kenya	Tea	27
Malawi	Tobacco	65
Rwanda	Coffee	25

Source: UNCTAD: The State of Commodity Dependence.

shows the key agricultural commodity export and its share of the export earnings as a percentage of GDP in the year 2009–2010 (UNCTAD, 2012).

Agriculture is important for the economy in Burundi given that it accounts for 36.4% of GDP which is mainly through coffee. Exports of coffee account for 70% of foreign exchange earnings.⁶ During the coffee boom of the 1970s and 1980s, coffee became an important commodity for Rwanda. Also coffee dependency increased on the back of high coffee prices as more land was devoted to coffee production (Kamola, 2007). However, in 1986 global over production of coffee led to a fall in coffee prices and by 1990 the price fall continued leading to a huge increase in debt. McKay and Arytee (2005) have documented that cocoa played an important role in Ghana's economic growth. The share of cocoa in the agricultural GDP of Ghana is approximately 19% and is predicted to play an important role to reach middle income status by providing the much needed foreign exchange earnings to help finance inputs for capital goods and the food processing sector (Minot and Daniels, 2005). Malawi is heavily dependent on tobacco in terms of export earnings. Tobacco accounts for 60% of export earnings and as much as 13% of GDP (Jaffee, 2003). It was believed that tobacco would be an engine of growth for Malawi, yet as noted in the study by Jaffee (2003) the income flow in rural areas has slowed down due to declining tobacco prices. In Benin, the agricultural sector accounts for 38% of GDP and employs 56% of the population who are economically active. Cotton in particular, is a significant crop, which accounts for 90% of the total agricultural exports and 60–70% of total exports (Minot and Daniels, 2005). This dependency on cotton makes Benin particularly vulnerable to cotton prices. For example, when cotton prices plummeted by 40% between January 2001 and May 2002, rural *per capita* income dropped by 7% (Minot and Daniels, 2005) challenging the view that rural populations are unaffected by international cotton prices. Burkina Faso is also a case in point when it comes to dependency on cotton prices. It was the cotton sector that led Burkina Faso to experience significant economic growth since 1994. Cotton production increased sharply in the 2000s and the share of cotton in export revenue peaked at 85% in 2007 compared to just under 40% in the 1990s.

To examine the relationships between *per capita* economic growth and agricultural commodity price shocks, we use an impulse response function analysis and compute

⁶African Economic Outlook 2014.

Table 3

Impulse response based test for symmetric response functions using the price increase specification (Mork model): P -values of the test of $H_0 : I_y^h(h, \delta) = -I_y^h(h, -\delta)$ for $h = 0, 1, 2, \dots, 7$ and δ being 1 standard deviation shock and 2 standard deviation shock. The P -values are based on the χ^2_{h+1} distribution based on 20,000 replications of the Mork model

h	Benin/Cotton		Burkina Faso/Cotton		Burundi/Coffee	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	1.00	1.00	0.99	0.97	0.85	0.33
1	1.00	1.00	1.00	0.99	0.93	0.60
2	1.00	1.00	1.00	1.00	0.98	0.77
3	1.00	1.00	1.00	1.00	1.00	0.89
4	1.00	1.00	1.00	0.99	1.00	0.95
5	1.00	1.00	1.00	1.00	1.00	0.98
6	1.00	1.00	1.00	1.00	1.00	0.99
7	1.00	1.00	1.00	1.00	1.00	1.00

h	Cameroon/Cocoa		Cote d' Ivoire/ Cocoa		Ghana/Cocoa	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	0.50	0.56	0.62	0.85	0.92	0.92
1	0.80	0.85	0.87	0.89	0.99	0.99
2	0.92	0.92	0.96	0.94	1.00	1.00
3	0.97	0.96	0.99	0.98	1.00	1.00
4	0.99	0.86	0.99	0.99	1.00	1.00
5	0.98	0.90	1.00	1.00	1.00	1.00
6	0.99	0.93	1.00	1.00	1.00	1.00
7	1.00	0.95	1.00	1.00	1.00	1.00

h	Kenya/Tea		Malawi/Tobacco		Rwanda/Coffee	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	1.00	0.99	0.54	0.63	0.97	0.94
1	1.00	1.00	0.82	0.88	0.79	0.53
2	1.00	1.00	0.94	0.97	0.92	0.71
3	1.00	0.96	0.77	0.87	0.97	0.85
4	1.00	0.91	0.86	0.94	0.99	0.93
5	1.00	0.96	0.92	0.97	1.00	0.97
6	1.00	0.98	0.95	0.99	1.00	0.99
7	1.00	0.98	0.97	0.97	1.00	0.99

the 1 and 2 standard deviation exogenous shocks to the structural model given by (2) and (3).⁷ We find that the graphs obtained for the impulse response functions show the responses to a positive and negative 1 standard deviation shock are almost identical for some countries; this result is broadly the same when considering the effect of a larger (2 standard deviation) shock.⁸

⁷We choose the impulse response function based tests over slope-based tests as the latter test focuses on the wrong null hypothesis (see Kilian and Vigfusson, 2011b for details).

⁸Note that for brevity, the full set of graphs of the impulse response analysis for the price increase and net price increase model are given in Figures A2 and A3 in the online Appendix accompanying this paper.

Table 4

Impulse response based test for symmetric response functions using the 3-year net price increase specification (Hamilton model): P -values of the test of

$H_0 : I_y^h(h, \delta) = -I_y^h(h, -\delta)$ for $h = 0, 1, 2, \dots, 7$ and δ being 1 standard deviation shock and 2 standard deviation shock. The P -values are based on the χ_{h+1}^2 distribution. We run 20,000 replications of the Hamilton model

h	Benin/Cotton		Burkina Faso/Cotton		Burundi/Coffee	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	0.04	0.08	0.04	0.08	0.48	0.53
1	0.12	0.21	0.12	0.21	0.75	0.80
2	0.17	0.30	0.22	0.35	0.09	0.16
3	0.29	0.46	0.35	0.51	0.13	0.25
4	0.35	0.54	0.48	0.65	0.15	0.34
5	0.33	0.60	0.55	0.74	0.23	0.44
6	0.44	0.71	0.67	0.83	0.26	0.46
7	0.48	0.77	0.76	0.89	0.34	0.55

h	Cameroon/Cocoa		Cote d' Ivoire/ Cocoa		Ghana/Cocoa	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	0.57	0.61	0.33	0.26	0.58	0.66
1	0.48	0.56	0.55	0.50	0.73	0.89
2	0.64	0.73	0.75	0.71	0.00	0.05
3	0.79	0.85	0.87	0.85	0.01	0.10
4	0.89	0.93	0.92	0.92	0.01	0.11
5	0.94	0.97	0.96	0.97	0.01	0.16
6	0.97	0.98	0.98	0.98	0.02	0.16
7	0.98	0.99	0.99	0.99	0.03	0.23

h	Kenya/Tea		Malawi/Tobacco		Rwanda/Coffee	
	1 SD shock	2 SD shock	1 SD shock	2 SD shock	1 SD shock	2 SD shock
0	0.89	0.80	0.71	0.74	0.06	0.13
1	0.94	0.94	0.07	0.14	0.14	0.26
2	0.98	0.98	0.12	0.23	0.25	0.43
3	1.00	1.00	0.21	0.36	0.30	0.52
4	1.00	1.00	0.33	0.50	0.43	0.66
5	1.00	1.00	0.38	0.59	0.55	0.77
6	1.00	1.00	0.48	0.69	0.64	0.83
7	1.00	1.00	0.55	0.75	0.74	0.90

However, as noted by Kilian and Vigfusson (2011a), these impulse response functions are subject to sampling uncertainty and it is important to proceed to test for symmetry. The results shown in Table 3 are the tests for symmetric response function based on the price increase model, and Table 4 that tests for symmetric response function based on the net price increase model.

In Table 3 we tabulate the probability values of the test for symmetric response functions using the price increase specification (Mork, 1989 model) given by (2). We set up the null hypothesis $H_0 : I_y^h(\delta) = -I_y^h(-\delta)$ which is the test for symmetric responses to a 1 or 2 standard deviation shock. The P -values are based on a Wald test that has an asymptotic χ_{h+1}^2 distribution based on 20,000 replications of the Mork

(1989) model. We find that for all time horizons up to 7 years, we do not reject the null hypothesis of symmetry. This is true for both small and large shocks. We conclude that there is no evidence of asymmetric responses of *per capita* GDP to agricultural price increases or decreases. In Table 4 we consider the responses to a 1 and 2 standard deviation shock using the net price increase specification (Hamilton, 1996 model). When we consider a small (1 standard deviation) shock, we find that for Benin, Burkina Faso and Rwanda there is some evidence of an immediate asymmetric response in the same year of the shock, but subsequently from the next year onwards the asymmetry disappears. For Ghana we find no initial asymmetric response to shock, but from the second year after the shock, there is evidence of asymmetry. A larger (2 standard deviation) shock is found to have a significant asymmetric response from Benin and Burkina Faso, but not Rwanda. Some evidence of asymmetric response at an intermediate time horizon is found for Ghana. In general, we can conclude that for all countries except Ghana the results from the net price increase model given by (3) are the same as those of the price increase model given by (2). The only exception is Ghana where we find asymmetric response in long horizons after a 1 standard deviation shock is felt. We also find that in the case of Ghana, for a larger shock, the asymmetric response is muted in that it only appears briefly for the second year after the shock. Overall, we conclude that there is very little evidence to suggest that a positive price shock leads to a significantly different response in *per capita* income, as opposed to a negative price shock.

5. Conclusion

We examine the importance of agricultural price shocks to economic growth in selected SSA countries. We adopt the definition of a commodity price shock as a 'price increase' due to Mork (1989) and a 'net price increase' due to Hamilton (1996, 2003) that allow us to trace whether the effect of a positive agricultural price shock on *per capita* income growth is different from a negative price shock for a selection of SSA countries. Applying impulse response analysis due to Kilian and Vigfusson (2011a), to uncover whether positive or negative agricultural price shocks evoke a different response to *per capita* economic growth, we find that there is very little evidence of such asymmetry. The SSA countries are heavily dependent on a single agricultural commodity and in recent years countries such as Burkina Faso, Malawi and Ghana have a modest share of export earnings from a single agricultural commodity export relative to the total agricultural exports. However, our study shows that the possible asymmetry that might exist due to the uncertainty in unexpected agricultural price shocks does not exist or appear to be too weak to be detected in the data.

Supporting Information

Additional Supporting Information may be found in the online version of this article:
Appendix S1. Scatter Plots and Impulse Response Functions

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